

**The effect of a steady flow and a chromospheric magnetic field on  $p$ - and  $f$ -modes**

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The combined effect of a chromospheric uniform magnetic field and a photospheric steady flow on the  $p$ - and  $f$ -modes is evaluated theoretically for a simple model of the solar plasma. The introduced flow is parallel to the horizontal magnetic field. This model may serve as a first approximation to assess the effects of the observed highly dynamical solar interior (e.g., subsurface meridional flows, convective motion, etc.) especially for high degree  $l$ .

Frequency changes due to the magnetic atmosphere and the steady flow are derived analytically in the long wavelength limit and are determined numerically for arbitrary wavelengths.

The results reveal the influence of flow on the  $p$ - and  $f$ -modes is more dominant than the influence of the atmospheric magnetic field for the small wavenumber limit. However for arbitrary wavelengths the effect of magnetic field might be stronger than frequency shifts caused by a steady flow.

The understanding of the effect of subsurface flows on the  $p$ - and  $f$ -modes might help us to contribute to the solution for the puzzle of helioseismic frequency shifts.

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